

Spatial distribution and diet of *Cephalopholis fulva* (Ephinephelidae) at Trindade Island, Brazil

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In this study we analyze the population structure and diet of the coney *Cephalopholis fulva* at Trindade Island, Brazil, through direct observation with SCUBA diving in 11 reef sites around the Island, up to 50 m deep. Diet was based on 77 individuals collected with speargun. Mean population density and biomass were estimated at 29 individuals/100 m² and 13 kg/100 m², respectively. This species is regularly distributed along the coastal environments of the Trindade Island, with no significant differences in densities and biomass detected among the different collection habitats (reef crest, reef slope, and reef plateau). However, significantly higher densities were observed micro-habitats with greater structural complexity, which may offer more shelter and food to *C. fulva*. Four food item groups were identified from the gut contents of *C. fulva*: Annelida, Crustacea, Teleostei, and Testudinata. It is the first record of predation of the green turtle *Chelonia mydas* hatchlings by the coney. Trindade Island seems to present the densest concentration of *C. fulva* in all Brazilian and Caribbean ecosystems inhabited by this species. Scarcity of competitors, predators, and fishing pressure may explain the high densities observed in the Island.

Foram analisadas a estrutura populacional e a dieta do catuá *Cephalopholis fulva* na Ilha da Trindade, Brasil. Os dados foram obtidos através de censos visuais com mergulho autônomo em 11 locais no entorno da ilha, em profundidades de até 50 m. A dieta e a proporção sexual foram baseadas na análise de 77 indivíduos coletados com arpão. A densidade populacional e biomassa foram estimados em 29 indivíduos/m² e 13 kg/100 m², respectivamente. A espécie apresentou distribuição uniforme nos ambientes costeiros da ilha, não tendo sido registradas diferenças significativa em sua densidade e biomassa entre os diferentes habitats estudados (crista, talude e platô recifal). Entretanto, foi observado preferência por micro-habitats de alta complexidade estrutural. Foram registrados quatro grupos de itens alimentares no conteúdo estomacal de *C. fulva*: Annelida, Crustacea, Teleostei e Testudinata. É feito aqui o primeiro registro de predação de juvenis da tartaruga-verde (*Chelonia mydas*) por *C. fulva*. Trindade parece apresentar os maiores valores de densidade para o catuá, quando comparada a outras localidades do Brasil e Caribe. A escassez de competidores, predadores e a pressão pesqueira são possíveis fatores que podem explicar as altas densidades observadas para *C. fulva* na Ilha da Trindade.

Key words: *Chelonia mydas*, Coney, Feeding ecology, Grouper, Oceanic islands, Reef fish.

Introduction

The distribution of fish species along a reef ecosystem is believed to be ruled by abiotic (*e.g.* depth, water quality, substrate type) and biotic (*e.g.* recruitment, predation, competition) factors (Sale, 1991; Bellwood & Wainwright, 2002; Mendonça-Neto *et al.*, 2008). Habitat type and substrate structural complexity have been suggested to be important environmental traits structuring reef fish populations (Ferreira *et al.*, 2001; Fox & Bellwood, 2007). These environmental traits are expected to influence fish distribution by offering structures as rocks and holes where fish can hide from predators and look for food under relatively safe conditions (Willis & Anderson, 2003; Overholtzer-McLeod, 2004). Food availability has also been reported to be an important factor structuring the reef

fish distribution (Nagelkerken *et al.*, 2001; Beukers-Stewart & Jones, 2004; Floeter *et al.*, 2007). Considering habitat preferences and food availability, the site inhabited by a given fish species is presumably selected in response to the optimization of net energy gain and avoidance of predators and competitors (Baltz & Jones, 2003). Trindade is the most isolated Brazilian island, located at 1,160 km from the Brazilian central coast in the eastern end of the Vitória-Trindade submarine ridge (Fig. 1). The island presents an emerged area of about 9.3 km² which is surrounded by a narrow shelf of 32 km² (0-50 m deep) mostly covered by fringing and rock reefs, and few species of corals, zoanthids, and sponges (Gasparini & Floeter, 2001; Pereira-Filho *et al.*, 2011). These reef environments comprise areas with diverse structural complexity regarding the presence and size of holes and rocks representing

optimal habitats for fish. Despite this island has been declared an ecological reserve, fishing is still allowed, and pelagic longline, trolling bottom line and handline have been reported around the island (Pinheiro *et al.*, 2010). Moreover, signs of top predators overfishing have been recently observed (Pinheiro *et al.*, 2010, 2011; Pereira-Filho *et al.*, 2011).

The coney, *Cephalopholis fulva* (Linnaeus, 1758), stands out since its abundance easily overcome all the other predator fish species in Trindade island (Pinheiro *et al.*, 2011). It is a relatively medium-sized fish (maximum length of 40 cm) from the Epinephelidae family that usually inhabits reef areas in tropical environments of the Western Atlantic Ocean (Heemstra & Randall, 1993). In other Brazilian waters, *C. fulva* is an abundant carnivore commonly found in coastal reefs, embankments and the oceanic islands of Fernando de Noronha and Atol das Rocas (Ferreira *et al.*, 2004; Fredou *et al.*, 2006; Martins *et al.*, 2007; Krajewski & Floeter, 2011). Described as a piscivorous and invertivorous fish (Randall, 1967; Heemstra & Randall, 1993; Lieske & Myers, 1994), *C. fulva* is believed to play an important role as a predator in reef habitats and adjacent areas in which it is capable of influencing the abundance of many available preys (Webster, 2003; Overholtzer-McLeod, 2004; White, 2007). This species represents an important fishery resource in the Caribbean Sea (Heemstra & Randall, 1993), and it has been extensively exploited in the Brazilian central coast (Klipel *et al.*, 2005). Despite its ecological and commercial importance, there are only few studies focusing specifically on the population dynamics of *C. fulva* in Brazil (Araújo & Martins, 2006, 2009; Freitas *et al.*, 2011). Due to its high abundance in Trindade Island (Pereira-Filho *et al.*, 2011; Pinheiro *et al.*, 2011), *C. fulva* stands out as a model organism to evaluate ecological issues such as diet and habitat preferences. In this study, the relationship between diet and distribution of *C. fulva* at coastal reef areas of Trindade island, was evaluated, focusing

particularly on its preferences for different habitat types and microhabitats with varying levels of structural complexity.

Material and Methods

The population structure of *C. fulva* was evaluated using underwater visual censuses (UVC; $n = 144$) carried out between April-June 2009 at 11 sites around the coast of Trindade Island (Fig. 1) during day light (9:00 to 16:00 h). Samples were composed by 20 x 2 m transects. The transect width was chosen to allow comparisons with other previously reported studies on the Brazilian coast (Ferreira & Gonçalves, 2006; Floeter *et al.*, 2007; Mendonça-Neto *et al.*, 2008).

Each site was separated into three major microhabitats where fish censuses were performed (Fig. 2). (1) The reef crest is located at the surf zone, with depths of about 3-6 m; (2) the reef slope, with depths varying between 6-20 m; and (3) the reef plate, the deepest habitat sampled, with depths >20 m and limited in the deepest portion by non-consolidated substrata. Structural complexity was assessed visually by classifying the substrate rugosity according the following three categories: high complexity (rocks and holes > 1 m in length and depth), medium complexity (rocks and holes < 1m), low complexity (lack of rocks and holes) (Floeter *et al.*, 2007; Pinheiro *et al.*, 2011; Simon *et al.*, 2011).

During UVC sampling, fish individuals were included in five length classes (0-5, 5-10, 10-20, 20-30, and 30-40 cm). Biomass was estimated using length through the weight-length relationships (Froese & Pauly, 2010). Mean density and biomass of *C. fulva* from the three coastal habitats and substrate-complexity levels were compared with the Kruskal-Whallis test since these data did not follow normal distribution.

Diet was characterized using data from the Tartaruga's reef (Fig. 1). This reef was selected because it is representative

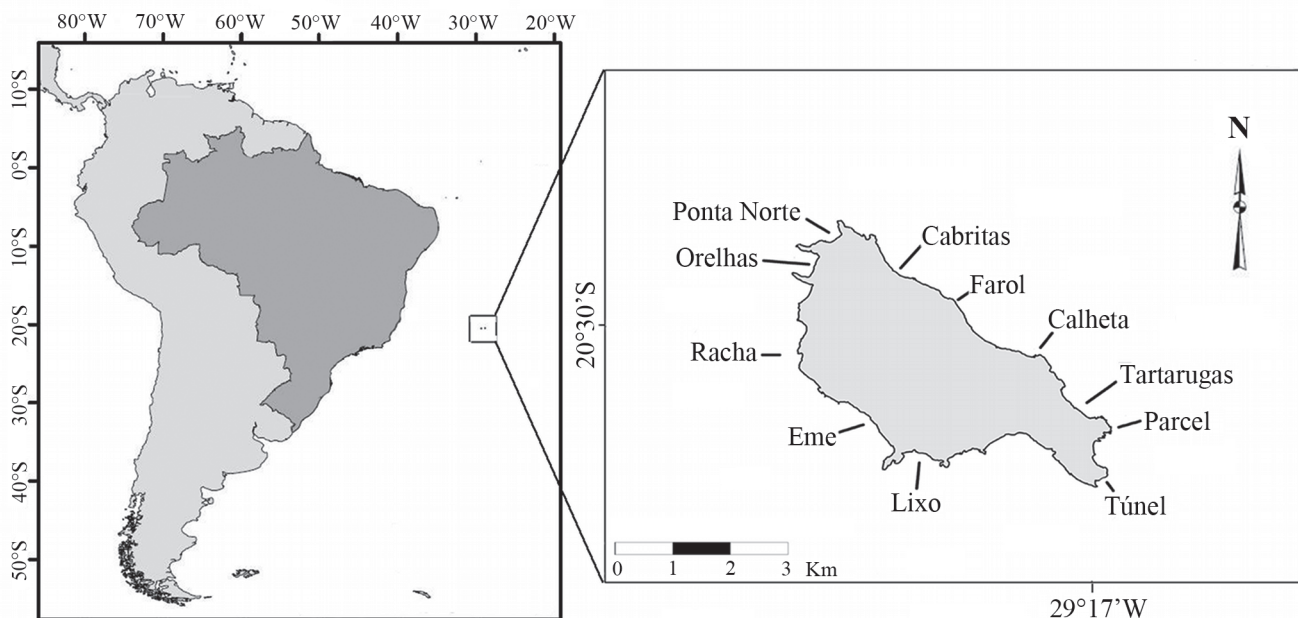


Fig. 1. Map of Trindade Island, off the Brazilian Central Coast, indicating the sampled sites.

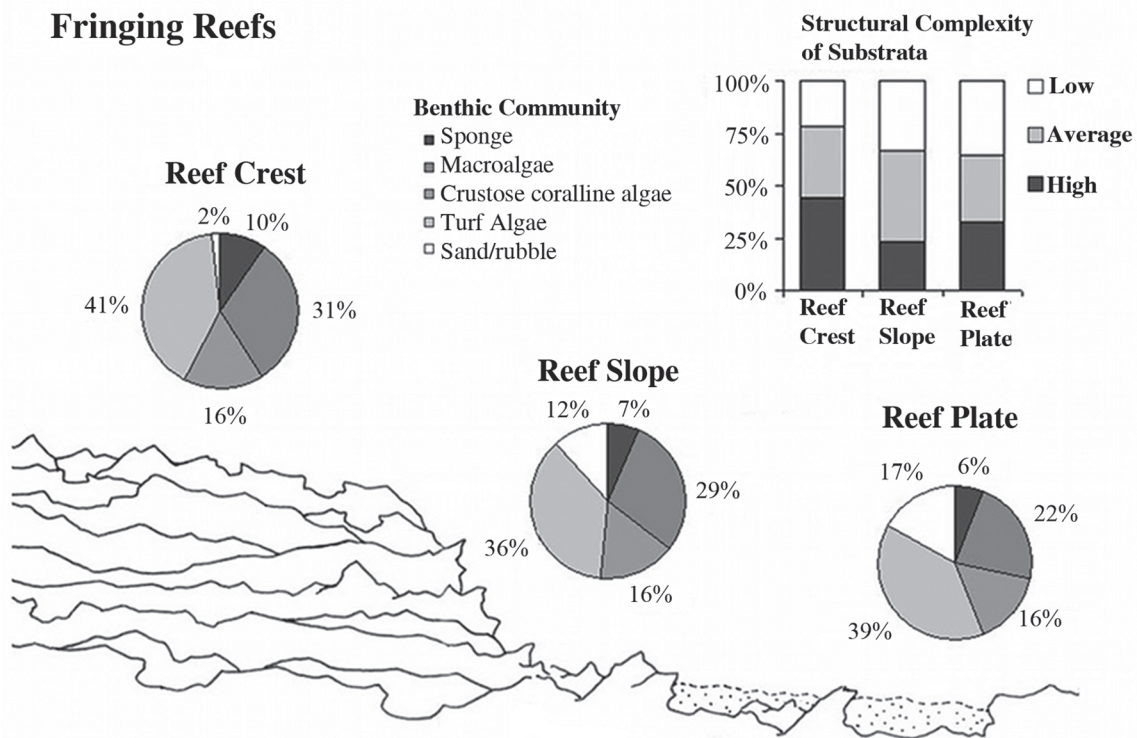


Fig. 2. Diagram showing profiles of fringing reefs of Trindade Island, Brazil. Benthic cover and substrate structural complexity of each habitat are presented.

of the main common reef environment across the island, and due to logistical aspects. Biological samples were collected from the reef crest, reef slope, and reef plate. A total of 77 individuals of *C. fulva* were collected using speargun. These fish were eviscerated and stomachs were preserved in ethanol 70%. Food items were identified to the lowest possible taxonomic level, counted and weighed. Diet composition was evaluated according to Pinkas *et al.* (1971), where the importance of each type of prey was assessed through its relative frequency of occurrence (%F), relative numerical frequency (%N), percentage of wet weight (%W) and the Index of Relative Importance [(IRI = %F (%N + %W)], expressed in percentage as suggested by Cortés (1997). Differences in diet between reef habitats regarding those major taxa were evaluated through Analysis of Similarity (ANOSIM). The data was square-root transformed and the similarity matrices were calculated using the Bray-Curtis index.

Results

The coney population at Trindade Island presented an overall mean abundance of 29 individuals/100 m² and biomass of 13 kg/100 m². Density values were highest for the 20-30 cm size class, while highest biomass values were recorded for the 30-40 cm size class (Fig. 3). The coney presented a broad distribution across the coastal habitats of the island, with no significant differences in density and biomass between the three reef habitats (KW; $p > 0.05$). However, abundance of *C.*

fulva varied significantly according to substrate complexity, with greater values recorded to microhabitats with higher structural complexity (KW; $p < 0.001$, Fig. 5).

From the 77 stomachs analyzed, 63 (81.8%) contained food. Food items were classified into nine categories (1 Polychaeta, 5 Crustacea, 2 Teleostei, 1 Testudinata) and two categories related to fragmented items of Crustacea and Teleostei (Table 1). The most important items (IRI) in decreasing order were: Testudinata (37%), Teleostei (32%), and Crustacea (30.3%). The most frequent items (FO %) were: Crustacea (69.4%) and Teleostei (41%). Numerically, the most important items were Crustacea (53%) and Teleostei (31%). Testudinata stood out in respect to weight, representing 81% of total weight found in the stomachs (Fig. 5) and about 9% of the total number of analyzed stomachs. Diet of the coney did not differ significantly between the three reef habitats when considering frequency of items (ANOSIM, Global R = 0.006, $p > 0.05$) nor items weight (ANOSIM, Global R = 0.006, $p > 0.05$).

Discussion

The coney population from Trindade Island was much more dense than the average range of densities about 0.15 to 12 individuals/100m² reported for Brazilian waters (Floeter *et al.*, 2007; Krajewski & Floeter, 2011) and from 0.1 to 19 individuals/100 m² reported for the Caribbean (Chiappone *et al.*, 2000; White, 2007). Recent studies on *C. fulva* in Trindade Island found population densities from about 10 individuals/100 m² (Pereira-

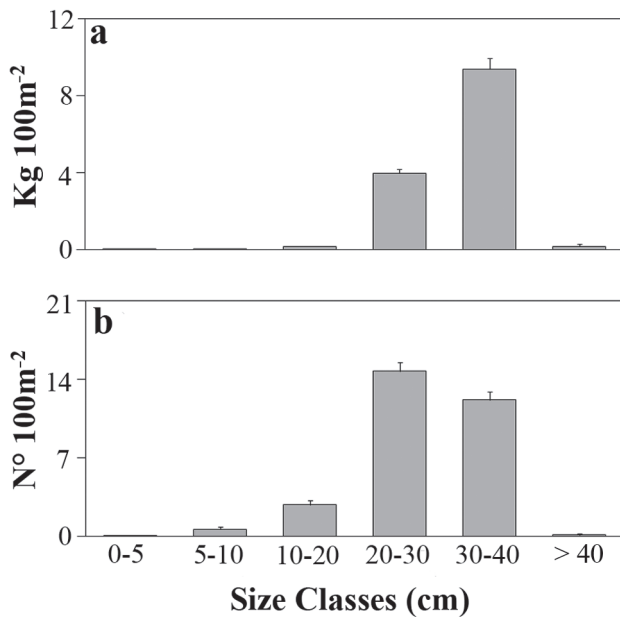


Fig. 3. Biomass (a) and Abundance (b) of different size classes of *C. fulva* at Trindade Island, Brazil. The error bars indicate standard error (SE).

Filho, 2011) and suggested Trindade waters may be already subject to overfishing due the lack of large predators. Some other studies in Brazilian waters have reported that *C. fulva* is usually associated with tropical reefs and its relative frequencies are usually lower than 1% of all observed fish species in these environments (Ferreira *et al.*, 2004; Francini-Filho & Moura, 2008). The high densities observed in our study may be explained by some factors, such as: firstly, Brazilian oceanic islands usually show lower diversity of small carnivores than that observed in coastal reef environments (Ferreira *et al.*, 2004). Thus, it is possible that *C. fulva* faces less competition with other carnivorous organisms in oceanic islands than in coastal areas, which could partially explain the high population density recorded here. The second factor would be the geographic isolation of the Island. Since Trindade Island is reasonably far from the continent, environmental issues as pollution, introduction of non-indigenous species and habitat loss are expected to be less intense than they are for more coastal areas and islands. In fact, the coney has been shown to be more abundant in oceanic banks and islands (Atol das Rocas, Fernando de Noronha and Trindade Island) than in the continental coastal regions (Floeter *et al.*, 2007; Krajewski & Floeter, 2011; Pinheiro *et al.*, 2011). Thirdly, fisheries at Trindade Island are mostly focused on larger fish species such as *Carcharhinus perezii*, *Xiphias gladius*, *Mycteroperca venenosa*, *Ephinephelus adscensionis* (Pinheiro *et al.*, 2010), which may also contribute to reduced competition and predation over *C. fulva*. It has been shown that in highly fished waters of the Caribbean, small non-targeted species such as *C. fulva* and *C. cruentatus* have become locally dominant (Chiappone *et al.*, 2000; Stallings, 2008; Mumby *et al.*, 2012). Therefore, we suggest

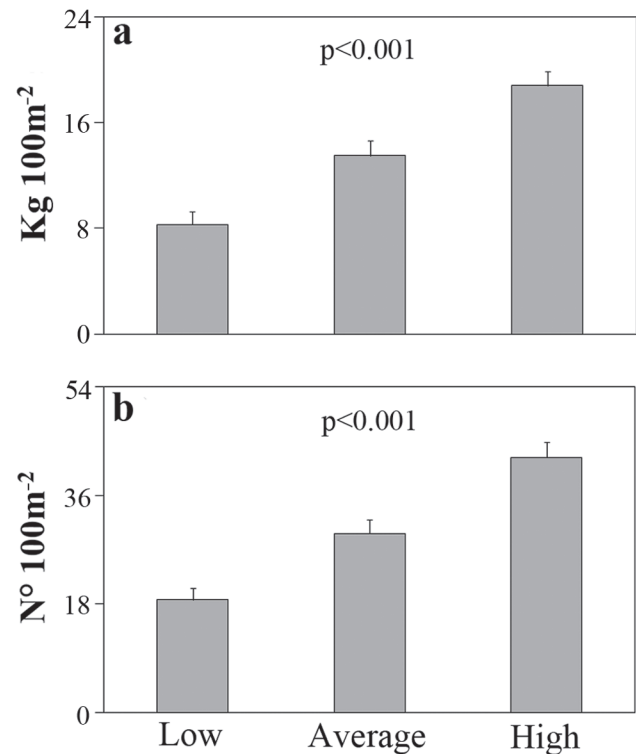


Fig. 4. Biomass (a) and Abundance (b) of *C. fulva* according to structural complexity of reef substrate at Trindade Island, Brazil. Error bars indicate standard error (SE).

the local fishery may be an important factor acting towards the increase of *C. fulva*'s density in Trindade Island.

In this study we have also observed that *C. fulva* was more abundant in more complex habitats. Environmental structural complexity has been reported as one of the main ecological attributes capable of influencing the community structure of reef fishes (Bell & Galzin, 1984; Ferreira *et al.*, 2001). In reef habitats, the fish's choice for a place to live takes in account a trade off between the competition intensity, food availability and risk of predation (Shpigel & Fishelson, 1991; Overholtzer-McLeod, 2004; Gibran, 2007). High densities of refuge-seeking invertebrates have been suggested to inhabit highly complex substrates (Webster & Hat, 2004), therefore, aggregations of small and medium-sized predators over these microhabitats may be related to their feeding strategy, as previously reported (Willis & Anderson, 2003; Almany, 2004; White, 2007). However, the diet of *C. fulva* was similar between different habitats, which allow suggesting that food availability is not likely to be an important factor explaining *C. fulva*'s habitat preferences. Unfortunately, our data do not allow evaluating the effectiveness of competition for food nor space with other fish species as a source of population structuring. Undoubtedly, highly complex substrates provide more protection against predators and may be an important factor inducing the increase of *C. fulva* abundance in such areas.

In addition to presenting the diet of this species for the first time in South-western Atlantic waters, we show evidence that

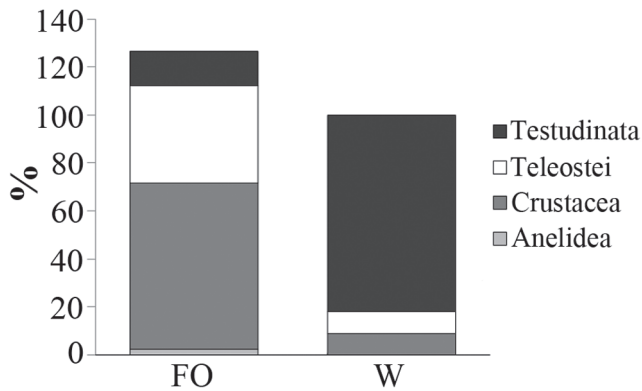


Fig. 5. Frequency of occurrence (% FO) and weight (% W) of food items present in *C. fulva*'s gut content at Trindade Island, Brazil.

reinforce the coney as an opportunistic predator. We have observed predation on seasonal resources as green turtle (*Chelonia mydas*) hatchlings, which represents the first record of this type of prey for *C. fulva*. Trindade Island, where a large amount of offspring hatch during four months every year (Moreira *et al.*, 1995), is the third largest reproductive site of *C. mydas* in the Atlantic ocean (Seminoff, 2002). Sea turtle hatchlings are known as a seasonal resource of high energy value for many opportunistic predators (Bouchard & Bjorndal, 2000). Considering the high abundance of *C. fulva* and that 9% of the sampled individuals were found to feed on green turtles, their estimated predation pressure on green turtles could be reasonably high around the shallow habitats of Trindade Island. In fact, *C. fulva* is an opportunistic predator that uses different foraging tactics (Sazima *et al.*, 2005).

Considering the ecological traits of *C. fulva* such as high abundance, wide spatial distribution and opportunist feeding habits, we suggest that this species play an important role in

Table 1. Frequency of occurrence (% FO), numerical frequency (% FN), percentage of wet weight (% W) and percentage of relative importance index of food items on gut contents of *C. fulva* at Trindade Island, Brazil. Bold prints indicate totals.

Items	%FO	%FN	%W	%IRI
Annelida	2.0	1.6	0.1	0.1
Polychaeta	2.0	1.6	0.1	0.1
Crustacea	69.4	53.3	8.3	30.3
Caridea	8.2	6.3	1.1	1.7
Brachyura	2.0	1.6	0.1	0.1
<i>Percnon gibbesi</i>	24.5	18.8	3.1	15.1
Stomatopod	14.3	10.9	2.8	5.5
Palinura	2.0	1.6	0.1	0.1
Crustacean fragments	18.4	14.1	1.1	7.8
Teleostei	44.7	34.4	10.5	32.5
<i>Ophioblennius sp</i>	2.0	1.6	0.2	0.1
<i>Thalassoma noronhanum</i>	6.1	4.7	0.3	0.9
Teleostei fragments	36.6	28.1	10.0	31.5
Testudinata	14.3	10.9	81.2	37.1
<i>Chelonia mydas</i>	14.3	10.9	81.2	37.1

the reef trophic dynamics of Trindade Island. In oceanic environments, the coney is capable of feeding on many prey-species, particularly the ones that show high abundance at some periods of the year, as we observed for the green turtle hatchlings. Therefore, *C. fulva* is likely to control the abundance of its preys, thus possibly improving the equilibrium and resilience of the reef environments of Trindade Island.

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